CORRECTIVE MEASURE STUDY WORK PLAN

FACILITY AT 3200 MAIN STREET KEOKUK, IOWA

Prepared for
United Technologies Corporation
Hartford, Connecticut
on behalf of Lear Corporation Automotive Systems

BTR Antivibration Systems, Inc.
Keokuk, Iowa

March 10, 2000

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Mr. Martin Kessler
ARTD/RCAP
U.S. Environmental Protection Agency
Region VII
901 N. 5th Street
Kansas City, Kansas 66101

Re: Facility at 3200 Main Street, Keokuk, Iowa

Dear Mr. Kessler:

On behalf of the United Technologies Corporation, Inc. (UTC) and BTR Antivibration Systems, Inc. (BTR), URS Greiner Woodward Cyde (URSGWC) is submitting two items pertaining to the Facility at 3200 Main Street in Keokuk, Iowa.

The first is a Corrective Measures Study Work Plan. The second is a letter providing response to EPA comments on the natural attenuation evaluation contained in the Update of Current Conditions Report. Three copies of each document are enclosed.

Please contact Mr. Rick Meyer at UTC if you have any questions or comments. He can be reached at (860) 728-7586.

Very truly yours,

URS Greiner Woodward Clyde

for

Klaas J. Doeden
Assistant Project Hydrogeologist

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Enclosure

cc: Rick Meyer (UTAS)
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This Corrective Measures Study (CMS) Work Plan for the former Sheller-Globe Facility (the Facility) has been prepared pursuant to Attachment III of the Final Administrative Order on Consent (the Order) for the facility at 3200 Main Street in Keokuk, Iowa. The Order is signed between Lear Corporation Automotive Systems (formerly known as United Technologies Automotive Systems Inc., and before that, as Sheller-Globe Corporation), and BTR Antivibration Systems, Inc. (formerly known as BTR Sealing Systems, and before that, as Schlegel Sealing Systems, Inc.), and the Environmental Protection Agency (EPA). The CMS will focus on identifying methods to reduce risk to human health and the environment associated with exposure to impacted soil and groundwater in the subject area.

1.1 FACILITY HISTORY AND OPERATIONS

The Facility, which began operation in 1914, has produced a variety of rubber products under a number of different owners. Products produced at the Facility included rubber tires manufactured by the Standard Four Tire Rubber Company beginning in 1914. Tire manufacturing operations continued until 1931 when the Standard Four Tire Rubber Company went bankrupt. The company reorganized, renamed as Rubber Industries, and began producing rubber gloves, hoses and other rubber products.

Rubber Industries was purchased by the Dryden Rubber Company in 1937. At that time, only chemically blown sponge rubber was manufactured. In 1949, the Dryden Rubber company was purchased by the Sheller Manufacturing Corporation. Additional products made at the Facility during World War II and the Korean War included gas masks and sponge rubber parts for the automotive industry. In 1955, production of urethane foam for use in the furniture and automotive industries began.

In 1966, the Sheller Manufacturing Corporation merged with Globe-Wernicke Industries, Inc. and on January 1, 1967 became the Sheller-Globe Corporation (SGC). Products manufactured at the Facility at that time included urethane foam (safety crash pads) and sponge rubber parts (weather-stripping) for the automotive industry. Production of urethane foam for the furniture industry was phased out in 1964. Tires, hoses, and gloves were no longer being produced at the Facility by that time. By 1984 urethane foam was no longer being compounded at the Facility for use in the automotive industry.

In 1988, SGC was purchased by United Technologies Corporation (UTC), Gibbons, Green & Van Amerongen and members of management. In 1989, SGC became a wholly owned subsidiary of UTC and changed its name to United Technologies Automotive Systems, Inc. (UTAS). In 1990, Schlegel Sealing Systems, Inc. (Schlegel) purchased the Facility while leasing a portion of the property to UTAS. UTAS began phasing out operations in 1991 and left the Facility completely in 1992. In 1999, UTC sold UTAS to Lear Corporation, which changed UTAS' name to Lear Corporation Automotive Systems, (LCAS, a wholly owned subsidiary of Lear Corporation). UTC continues to implement the Order on behalf of LCAS.

Schlegel was purchased by BTR Sealing Systems, Inc (BTR) in 1989 and later the owner of the Facility became BTR Antivibration Systems, Inc. (BTR). BTR is the current owner and operator of the Facility and continues to manufacture rubber parts for the automotive industry.

1.2 PURPOSE AND OBJECTIVES OF THE CMS

The overall purpose of the CMS is to evaluate corrective measures alternatives, and to recommend the corrective measure or measures, if any, to be undertaken at the Facility. The primary contaminants of concern are volatile organic compounds (VOCs) present in soil and groundwater in the general vicinity of the Chemical Mixing Building.

The objectives of the CMS Work Plan are as follows:

- Outline an approach for the determination of site-specific cleanup goals,
- Provide a framework to identify, evaluate, and screen technologies (including the existing SVE system) for possible corrective actions at the facility, and
- Describe the process for further evaluating natural attenuation as a possible remedy for the Facility.

1.3 CMS WORK PLAN ORGANIZATION

The CMS Work Plan is divided into several sections addressing the requirements of Attachment III of the Order.

- Section 2.0 describes the overall approach for conducting the CMS.
- Section 3.0 presents the methods and procedures to be used in development of site-specific cleanup standards for soil and groundwater in each of the Areas of Concern.
- Section 4.0 summarizes key site conditions, and presents the technologies to be evaluated during the process of identifying, screening, and developing corrective measure alternatives for the site.
- Section 5.0 describes how the detailed evaluation and selection of a final corrective measure alternative or alternatives will be performed.
- Section 6.0 presents the methods to be followed for further evaluating natural attenuation as a possible remedy for the groundwater at the Facility.
- Section 7.0 outlines the groundwater monitoring schedule for the site.
- Section 8.0 summarizes the project management plan, and includes a list of deliverables and schedule for each.

The CMS will include two major series of tasks. The first is the development of media cleanup standards for the Facility. The second is the evaluation of corrective measures technologies and alternatives. These two series of work activities are closely related. Although the evaluation of corrective measures technologies can be initiated concurrent with the development of cleanup standards, the detailed evaluation of alternatives can not be completed until after the cleanup standards are finalized. In addition, the schedule for completing the evaluation of alternatives is dependent on the schedule for conducting further groundwater monitoring to evaluate natural attenuation. Finally, it is also advantageous to complete at least the first year of operation of the existing Soil Vapor Extraction/Vacuum Groundwater Recovery (SVE/VGR) system prior to completing the evaluation. The interrelationship of these tasks is discussed further in the subsequent sections describing each task.

The process for developing media cleanup standards has been proposed in three steps, each to be reported through submittal of a technical memorandum:

1. Exposure pathway analysis
2. Identification of risk equations and transport models
3. Calculation of cleanup goals

These steps are further described in Section 3.

The technical evaluation of corrective measures will be performed in two steps:

1. Identification, Screening, and Development of Corrective Measures Alternatives
2. Evaluation of Corrective Measures Alternatives

The first step will be initiated concurrent with the development of the media cleanup standards and is described in Section 4. The second step will be completed after finalization of the cleanup standards. This step is described in Section 5.

The EPA is in the process of implementing a set of administrative reforms known as the RCRA Cleanup Reforms with the intent of achieving faster, more efficient cleanups at RCRA corrective action sites (EPA, July, 1999). To this goal, this work plan proposes a focused CMS. The focused approach is applicable at the Facility given the limited area of contamination, the large amount of characterization data that has been collected for the size of the site, and the valuable performance data that is currently being generated through the operation of the existing SVE/VGR remediation system. The focused CMS is also consistent with EPA guidance (<u>RCRA Corrective Action Plan</u>, May 1994) that states, "The scope and requirements of the CMS . . . need to be balanced with the expeditious initiation of remedies and rapid restoration of contaminated media…"

EPA's RCRA Cleanup Reforms identify two environmental indicators as key measures of progress towards meeting reform goals. These are "Current Human Exposures under Control" and "Migration of Contaminated Groundwater under Control." In order to aid EPA in assessing progress toward meeting cleanup reform goals for the Facility, these two key indicators will be addressed in both the cleanup standards and CMS deliverables produced by this project.

Cleanup goals for the Facility will be developed using a risk-based approach that takes into account a number of site-specific factors, such as land use, potentially exposed populations, lack of a potable aquifer, etc. This type of information, which is commonly developed as part of a Baseline Risk Assessment, is used to identify the populations, media, and chemicals of concern. Risk-based cleanup goals are subsequently developed for only those chemicals and media of concern that have been identified as posing a potentially unacceptable risk to any exposed populations

Because a Baseline Risk Assessment has not been performed, site-specific information required to calculate cleanup goals will be developed in a series of three technical memoranda (TM), as identified below:

The first TM will provide an exposure pathway analysis for contaminated media, using standard EPA protocols. The purpose of this first cleanup goal submittal is to come to agreement with EPA about the chemicals and media that require cleanup, and the receptor(s) (human and environmental) that the cleanup goals are designed to protect.

An exposure pathway refers to the mechanism by which a receptor may come in contact with a chemical. As defined by EPA risk guidance (1989), there are four major elements that characterize a complete exposure pathway. These elements are:

- A source and mechanism of chemical release
- A transport medium for the chemical
- A point of potential receptor contact with the medium (e.g. exposure point)
- A route of exposure (e.g. ingestion) for the receptor to come into contact with the chemical

For an exposure pathway to be complete, all four elements must be present. The absence of any one of these elements results in an incomplete exposure pathway for which site-related health risks do not exist. Thus, the evaluation of potential exposure pathways is necessary to focus on only those pathways that have potential to impact receptors (i.e., cleanup goals need only be developed only for those contaminated media with complete exposure pathways).

The exposure pathway analysis presented in TM # 1 will be performed using a site conceptual exposure model (SCEM) to help identify potentially complete/significant pathways. The SCEM specifically addresses each of the four components of an exposure pathway. In addition to the SCEM, the following site-specific information will be provided in the TM:

- Chemicals of Concern (COCs) and the methodology used for their selection
- A discussion of current and likely future land and groundwater use at the site and in the surrounding community
- A qualitative discussion of the nature and extent of contaminated media, as it relates to potential human exposure
- Identification of receptor populations that could reasonably be expected to come into contact with site-related contaminants

This evaluation will be used to identify the COCs, the media that require cleanup, the receptor population(s) that the cleanup goals are targeted to protect, and the scenarios that will be used to develop the cleanup goals.

The purpose of TM # 2 is to come to agreement with EPA for the technical approach to be used to calculate cleanup goals. Risk-based cleanup goals can be developed using a number of different equations/models. The choice of the most appropriate models and exposure equations to use in the cleanup goal calculations is dependent on the scenario/population being evaluated and the media that require cleanup. The purpose of TM # 1 is to identify these scenarios/populations/media. Upon approval of TM # 1, a second TM (TM # 2) will be submitted that identifies the specific risk equations and transport models that will be used in the cleanup goal calculations. This will include a description of all major proposed target risk levels, input assumptions, and exposure factors that will be used to calculate the site-specific cleanup goals.

Upon approval of TM # 2, health-protective cleanup goals will be calculated for Facility contaminants and submitted in TM # 3. This TM will incorporate the information provided in the first two TMs so as to provide complete documentation in one source document.

4.1 KEY SITE CHARACTERISTICS

The following sections present a summary of the key site characteristics pertinent to the evaluation of corrective measures as identified during investigation activities. A detailed discussion is presented in the September 1999 Update of Current Conditions Report prepared by URS Greiner Woodward Clyde (URSGWC) and previously submitted to EPA.

Source Areas and Contaminants of Concern

Previous investigations at the Facility have detected the presence of VOCs in soil and groundwater in the general area around the Chemical Mixing Building. The primary source of soil and groundwater contamination was the five underground solvent product tanks formerly located adjacent to the east side of the Chemical Mixing Building. The five tanks were removed in 1989. In addition to the USTs, there were several additional potential source areas identified which included leakage from an underground pipeline connecting the solvent product tanks to the main facility, leakage from a former underground gasoline tank, and the drum storage area. An additional source of limited soil and groundwater VOC contamination is present in the vicinity of MW-20. However, the concentrations in that area are significantly lower than in the vicinity of the former underground tanks.

Investigations in the area surrounding the source areas identified the following chlorinated and non-chlorinated compounds for the Facility: toluene, hexane, methyl ethyl ketone (MEK), methylene chloride, trichloroethene (TCE), 1,1,1-trichloroethane (TCA), butanol, ethanol, acetone, benzene, carbon disulfide, carbon tetrachloride, chloroethane, 1,1-dichloroethane (DCA), 1,2-DCA, 1,1-dichloroethene (DCE), 1,2-DCE, ethyl benzene, 4-methyl-2-pentanone (MIBK), 1,1,2,2-tetrachloroethane, tetrachloroethene (PCE), 1,1,2-TCE, vinyl chloride, and xylenes.

Key Topographic, Geologic, and Hydrogeologic Features

Facility topography plays an important role in limiting the migration of contaminants. The original topography in the investigation area has been substantially modified over the years to accommodate development of the Facility. A general cross-section was developed to represent the distinct features produced with the modifications (Figure 1).

The topography and the geologic units at the Facility are discussed in detail in the September 1999 Update of Current Conditions Report. In general, the ground surface in the investigation area has a topographic high in the area directly between the southwest side of the Facility and the Chemical Mixing Building. This topographic high was artificially produced with fill material referred to as "Plant Area Fill." To the south and west of the Chemical Mixing Building, the Plant Area Fill material rapidly slopes down to the edge of the Employee Parking Lot where the Plant Area Fill material ends. Topography in the Employee Parking Lot area is formed from an Engineered Fill material, which was installed so that it gently slopes toward a natural topographic low in the center of the Employee Parking Lot.

The fill materials from the two areas have different characteristics. The Plant Area Fill was placed to increase the area available for plant expansion. The source of the Plant Area Fill is not known and the material and degree of compaction appears variable. The Plant Area Fill generally consists of firm to stiff, olive-brown to dark brown, medium plastic, silty clay with varying amounts of sand, gravel, brick, rubber and debris. The Engineered Fill material appears to be glacial till that was moved to fill the former northwest trending drainage for construction of the Employee Parking Lot. The degree of compaction appears greater and more consistent than the plant area fill. The engineered fill generally consists of soft to firm, yellowish-brown to olive-brown with some gray mottling, low plastic, silty clay with some sand and gravel.

The two fill material areas are underlain by a native glacial till. The glacial till consists of an oxidized and weathered upper till zone underlain by a dense unoxidized and unweathered till zone. The uppermost glacial till zone generally consists of oxidized, firm to stiff, yellowish-brown to light brown with gray mottling, medium to highly plastic clay with iron-oxide staining, vertical fractures and fine to medium sands with a trace of fine gravel. Fractures were typically encountered to approximately 30 feet below ground surface (bgs). Many fracture surfaces at shallow depths in the oxidized till were iron stained. The upper till zone contains discontinuous silty sand lenses which range typically from several inches to several feet thick. The sand lenses tend to be isolated, discontinuous, and lenticular, with a high percentage of fines. At approximately 30-35 feet bgs, the glacial till transitions from being oxidized and weathered to unoxidized and unweathered. In this transition zone, the density increases significantly and the color begins to change to where the lower unoxidized glacial till becomes very stiff to hard, dark gray with almost no fractures.

Contaminant Migration and Containment On-Site

The primary plume consisting of chlorinated and non-chlorinated VOCs has migrated approximately 160 feet away from the former underground solvent product tanks area and the Old Hazardous Waste Storage Area to the Employee Parking Lot. Chemical data plus groundwater elevation contours indicate that the plume is not moving off-site. A secondary plume, consisting primarily of non-chlorinated VOCs at much lower concentrations, has not moved a great distance from the source area near MW-20. The secondary plume is very localized and recent data indicates that concentrations are declining in that area and are below MCLs.

The glacial tills are composed primarily of clays. Investigation and monitoring data have shown the soils to be "tight" and yield small amounts of water. Monitoring wells typically can be drawn down or completely dewatered at very low flow rates.

Site Physical Features

The contaminated area of the property is industrialized and is located in a very active portion of the Facility. Multiple facility structures are present in the area: the main plant building, the Chemical Mix building, an above-ground storage tank, fences, gates, sidewalks, etc. Overhead and buried utilities are present at the Facility. The area receives heavy vehicle traffic. Trucks and railcars enter the Facility, load, and unload in the area. South 31st Street and the Employee Parking Lot receive frequent vehicle traffic and workers enter the Facility along a sidewalk and plant entrance that are located in the area of concern. Finally, the majority of the area is paved to support the truck traffic and worker vehicles. All of these factors will need to be considered when evaluating corrective measures for the Facility.

4.2 CORRECTIVE MEASURES TECHNOLOGIES TO BE REVIEWED

4.2.1 Review of the Pre-Investigation Evaluation of Corrective Measures Technologies Report

In December 1991, Woodward-Clyde prepared a Pre-Investigation Evaluation of Corrective Measures Technologies Report (PECMTR) for the Facility. The purpose of the report was to identify potential corrective measures technologies that may be used for the containment, treatment, remediation, and/or disposal of potential contaminated media which may be present at the Facility. Eleven potential corrective measures technologies for soils and/or groundwater were identified for consideration:

1. No Action (Soil and Groundwater)
2. Institutional Controls (Soil and Groundwater)
3. Capping Methods (Soil)
4. Bioreclamation (Soil)
5. Excavate and Remove to Off-Site Location (Soil)
6. Excavate and Consolidate into a landfill or waste management area on-site (Soil)
7. Soil Vapor Extraction (Soil)
8. Soil Washing (Soil)
9. Thermal Treatment Methods (Soil)
10. Other Physical In-situ Methods (Soil)
11. Hydraulic Control of Groundwater Movement including passive recovery systems, containment systems, and active recovery systems (Groundwater).

This list of technologies was prepared prior to conducting the RFI and was based on possible contaminants that might be encountered based on what was known of the site at that time. For example, metals, semi-volatile organics, and oils were considered possible contaminants at that time, and are no longer a concern for the CMS. As such, many of these technologies are no longer applicable. As described later, a refined list of technologies has been developed for consideration during the CMS. The following technologies identified in the PECMTR will be carried forward into the CMS process and supplemented by additional technologies:

- No action
- Institutional controls
- Soil vapor extraction

4.2.2 Soil Vapor Extraction System Pilot Study and Interim Measures Implementation

Envirogen conducted a SVE pilot study at the Site in May 1992. Methodology and results of the pilot study are documented in the report, Soil Vapor Extraction Pilot Study (April 1, 1993). Envirogen determined SVE to be a feasible remedial technology for the Facility as a result of that study. Subsequently, Envirogen submitted an Interim Measures Remediation Work Plan: Soil Vapor Extraction System Design (January 30, 1998) to the EPA for approval. The document was approved by the EPA on August 27, 1998. The system was installed in accordance with the approved work plan. Construction and start-up of the system is detailed in the SVE Construction and Start-up Report (May 1999). The SVE system operation began on February 25, 1999.

The ultimate goal of the SVE system is to reduce the average concentration of VOC contaminants in vadose zone soils (above the capillary fringe) in the area of contamination to acceptable levels. The purpose of the remediation system is to minimize the source of contaminants that may migrate to and degrade the underlying groundwater. Concurrent with the operation of the SVE system, groundwater existing in the Plant Area Fill material within the former tank excavation area is removed and treated through the use of VGR. Dewatering of soils will enhance the performance of the SVE system in that area.

The SVE treatment area includes those soils enclosed within the perimeter of the influence of the SVE wells to an average depth of approximately thirteen feet below grade (approximately 11,000 cubic yards). The Facility is treated using 82 SVE wells and 33 VGR wells. The SVE system utilizes both vacuum and injection blowers, and is operated using an open-loop configuration (air collected from the vacuum side of the SVE system is discharged directly to the atmosphere). As designed, the SVE system and well layout will eliminate potential nodes of non-treatment that may occur within the treatment area. Each well can be operated under vacuum or pressurized conditions. SVE wells will be changed from injection to withdrawal to allow redirection of airflow for elimination of nodes where reduced treatment might occur. The vacuum lines are connected to an in-line filter for removal of particulates and a water extraction system that includes a knockout tank for removal of condensate water.

The VGR system removes water accumulated in and around the former tank excavation. The water is transferred into a holding tank and pumped through two granular activated carbon (GAC) vessels in series. The treated water is then discharged into an existing sanitary sewer line leading to the City of Keokuk Wastewater Treatment Plant. A permit was obtained for discharge of the water to the POTW.

Start-up of the remediation system began in March 1999. Since start-up, composite off-gas samples have been collected to monitor the total quantity of VOCs removed by the system. The composite sample data and the withdrawal blower flow rate are used to calculate the total mass of contaminants removed from soils. The total mass removed in pounds of contaminants for the compounds of concern is approximated using the Ideal Gas Law. Based on these calculations, the cumulative total mass removed since the start-up of the SVE system through the end of September 1999 is 3,060 pounds of total targeted compounds (TTC).

4.2.3 Technologies to Evaluate During the Corrective Measures Study

Based upon information that was gained during investigation activities performed since the preparation of the PECMTR and through operation of the SVE/VGR system, a refined list of technologies will be evaluated during the Corrective Measures Study. The following technologies will be evaluated:

1. No Action

2. Institutional Controls
3. Continue operation of existing SVE/VGR system
4. Expansion of the existing SVE/VGR system
5. Natural attenuation
6. Enhanced in-situ biodegradation

A brief description of each of the technologies is presented below.

1. No Action. This technology consists of the site remaining "as-is" and no provisions are made for the implementation of monitoring activities or remediation technologies of the contaminated media. This option would be applicable to sites if the risk to human health and the environment are assessed as acceptable based on applicable regulatory guidelines. Considerations during the assessment would include potential receptors and exposure pathways for the contaminated media at the site.
2. Institutional Controls. Institutional controls involve the creation and implementation of responsibilities for regulating and limiting human and environmental contact with the media and contaminants. This technology may include physical restrictions such as limiting site access by a security fence, zoning or deed restrictions on future site activities to limit exposure to the contaminants, and restrictions on site construction activities. This alternative typically includes a sampling program to monitor the long-term potential migration of contaminants and the effectiveness of the institutional controls to prevent exposure to potential receptors.
3. Continued Operation of the Existing SVE/VGR System. A soil vapor extraction (SVE) and vacuum groundwater recovery (VGR) system was installed in the former underground solvent product tanks area beginning in October 1998. The purpose of the SVE/VGR system is to remove compounds from the source area soils and minimize impact to groundwater through volatilization and recovery of the target compounds. This system is described in further detail in Section 4.2.2. This technology will evaluate the continued operation of the SVE/VGR system to meet the CMS objectives.
4. Expansion of the Existing SVE/VGR System. This technology will evaluate the expansion of the current SVE/VGR system. System expansion may include the installation of additional vacuum, injection, or VGR wells, modification of current extraction and injection flowrates, or modifications to system operating parameters (i.e., pulsed sparging cycles).
5. Natural Attenuation. Natural attenuation (also known as intrinsic remediation) of compounds in groundwater results from the integration of several subsurface attenuation mechanisms, both destructive and nondestructive. These processes include biodegradation, dispersion, sorption, volatilization, and dilution via infiltration. The objective of this process is to document that natural processes occurring at the site will reduce the concentrations of the target contaminants to below regulatory standards before potential receptor exposure pathways are completed.
6. Enhanced In Situ Biodegradation. The chlorinated and non-chlorinated compounds identified at the Facility are susceptible to biological degradation to a varying extent. This technology will evaluate the effect of possible modifications or supplements to the SVE/VGR system,

such as nutrient addition, bioaugmentation, and co-substrate addition to enhance biological degradation and meet CMS objectives.

4.3 TECHNOLOGY SCREENING PROCESS AND DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

4.3.1 Technology Screening Process

The technologies identified in Section 4.2.3 will be screened to eliminate those that may prove infeasible to implement, that rely on technologies unlikely to perform satisfactorily or reliably, or do not achieve the Facility cleanup goals within a reasonable period. This screening process will focus on eliminating the technologies that have severe limitations for the Facility's waste and site specific conditions. The screening step will also eliminate any technologies that have inherent technology limitations.

The following site, waste, and technology characteristics will be used to screen out inapplicable technologies:

Site Characteristics

Site data collected during the facility investigations and operation of the SVE/VGR remediation system will be reviewed to identify conditions that may limit or promote the selection of certain technologies. For example, a key consideration at this site is the soil type, the clay glacial tills. The till formation is tight and yields little water during pumping of existing monitoring wells. All technologies that are not applicable to site conditions will be eliminated from further consideration.

Waste Characteristics

Identification of contaminant characteristics that limit the effectiveness or feasibility of the technologies is an important criteria during the screening process. All technologies that are clearly limited or inappropriate for the Facility contaminant characteristics will be eliminated from further consideration.

Technology Limitations

During the screening process, the level of technology development and commercialization stage, performance record, and inherent installation, operation, and maintenance issues will be identified for each technology considered. Technologies that are not ready for field implementation, are considered unreliable or unpredictable, or are poor performers may be eliminated from further consideration. However, innovative treatment technologies (such as technologies other than pumping with conventional treatment for groundwater) will be considered for the site. Innovative treatment technologies (i.e., soil vapor extraction, bioremediation, monitored natural attenuation) may require additional efforts to gather data, analyze options, and implement the technology at the Facility. However, the current SVE system will provide a large volume of site-specific operating and performance data.

4.3.2 Development of Corrective Measure Alternatives

After completion of the screening process, the technologies most suitable for the site will be retained for detailed analysis. The retained technologies will be used to form one or more corrective measures alternatives. Each alternative may consist of a single technology or a combination of technologies.

The results of the screening process, the description of the alternative or alternatives retained for detailed analysis, and the reasons for excluding technologies from further analysis will be presented concurrent with the Cleanup Goals Technical Memorandum #2.

For each corrective measures alternative retained after the initial technology screening process, a detailed evaluation will be performed to document the ability of the alternative to meet the following technical standards:

- **Protect human health and the environment.** Each alternative will be assessed based on mitigation of short- and long-term potential exposure to residual contamination and protection of human health during and after implementation of the alternative. Each alternative will be evaluated to determine the level of exposure to contaminants and the mitigation measures. The relative reduction of impact will be determined by comparing residual levels to the cleanup standards as determined in Section 2.0. In addition, a brief environmental assessment for each alternative will be prepared. The assessment will include a qualitative evaluation of the short- and long-term beneficial and adverse effects on environmentally sensitive areas, if any, posed by the alternative.

- **Attain media cleanup standards.** Remedies will be required to attain the site-specific cleanup goals as discussed in Section 2.0. Since the media cleanup standards play a large part in technology selection, the determination of cleanup goals as discussed in Section 2.0 must be completed prior to performing this detailed evaluation of alternatives. In addition, an estimated schedule for each alternative to meet the site-specific cleanup goal will be presented.

- **Control the source of releases.** Each alternative will be evaluated to determine its ability to control further releases of contaminants that may pose a threat to human health or the environment. The CMS Report will also address whether or not further source control measures are required.

- **Compliance with applicable standards.** Each alternative will be evaluated to ensure that corrective actions are conducted in compliance with applicable state or federal regulations such as closure requirements or land disposal restrictions.

In addition to the technical factors listed above, five additional general factors, representing a combination of technical and management controls, will be considered in evaluating the alternatives. The five general decision factors include:

- **Long-term reliability and effectiveness.** The alternatives will be evaluated based on effectiveness under similar site conditions, whether failure of a technology component will have an immediate impact on identified receptors, and the flexibility of the alternative to accommodate changing site conditions.

- **Reduction in the toxicity, mobility or volume of wastes.** In general, remedies capable of substantially reducing the potential for future environmental releases or other risks to human health and the environment are preferred. Estimates of the ability of the alternatives to reduce contaminant toxicity, volume, and/or mobility will be made. If feasible, this may include a comparison of initial site conditions to anticipated post-treatment conditions.

- **Short-term effectiveness.** Short-term effectiveness will be evaluated to consider the effect of remedial activities on Facility operations, risk to workers and the environment, and the requirement for special protective measures. Evaluation factors may include the risk of fire, explosion, and exposure of receptors to the contaminants associated with the treatment of the contaminants.

- **Implementability**. Implementability is often the determining factor in selection of a remedy. The implementability of each alternative will be assessed based on administrative activities required (i.e., permits, off-site approvals, etc.) and the time associated with the administrative activities; the constructability, implementation timeline, and the time to achieve beneficial results; the availability of the required technical resources and materials; and the availability of the prospective technologies for each alternative.
- **Cost.** The relative cost of a technology will be considered, especially if several different technical approaches offer equivalent protection of human health and the environment but vary in cost. A relative cost estimate will be prepared for each corrective measure alternative and will include the costs for tasks such as engineering, site preparation, construction, implementation, operation and maintenance, sampling, analytical, and permitting activities.

A final Corrective Measure Alternative will be recommended using the criteria set forth above. The recommended alternative will be presented in the CMS Report. The report will contain a detailed description of the evaluation process described in this section and the rationale for the recommendation. The report will include summary tables for each alternative which highlight the tradeoffs between protection of human health and environment, the ability to attain cleanup goals, long- and short-term effectiveness, implementability, cost, and other pertinent factors.

The Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, (EPA, 1998) and the Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites (ASTM, 1998) identify three lines of evidence that may be used to evaluate whether natural attenuation of chlorinated and non-chlorinated VOCs is a viable corrective measure option. The three lines of evidence are:

- **First Line of Evidence** - Historical soil or groundwater data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentrations over time at appropriate monitoring or sampling points;
- **Second Line of Evidence** - Hydrogeologic or geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels;
- **Third Line of Evidence** - Data from field or microcosm studies (conducted in or with actual contaminated site media) which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern.

The EPA Technical Protocol states that unless EPA or the implementing state agency determines that the data supporting the first line of evidence are of sufficient quality and duration to support selection of natural attenuation as a corrective measure, data supporting the second line of evidence will also be required. Where data supporting the second line of evidence is inadequate or inconclusive, data supporting the third line of evidence may also be necessary.

A preliminary evaluation of data supporting the first two lines of evidence was presented in the Update of Current Conditions, Facility at 3200 Main Street, Keokuk, Iowa, (URSGWC, 1999). The preliminary evaluation consisted of evaluating contaminant concentrations over time in a number of wells (first line of evidence) plus geochemical indicators of natural attenuation (second line of evidence). Results of the evaluation indicated that concentrations of a number of VOCs have decreased over time. In addition, a number of geochemical indicators suggested that natural attenuation is occurring. Based on these results, further evaluation of natural attenuation in the CMS was recommended.

Natural attenuation will be further evaluated in the CMS by a more rigorous evaluation of the first and second lines of evidence. The third line of evidence will not be evaluated. Data collection activities to support these two lines of evidence include additional groundwater sampling to evaluate concentrations and distribution of VOCs and geochemical indicators of natural attenuation including parent and daughter compounds, electron acceptors, and metabolic byproducts. Specific analytical parameters are included in Table 1. Groundwater samples to be analyzed for these parameters are scheduled to be collected in May 2000. The preliminary natural attenuation evaluation was performed on data collected prior to the startup of the SVE/VGR system. The May 2000 sampling event is scheduled after the system has operated for a year. Evaluation of the first and second lines of evidence, will be based on data from the May 2000 sampling event as well as historical data.

The Update of Current Conditions Report prepared in September 1999 was essentially a conceptual site model. Recognizing that the conceptual site model is an important component of a natural attenuation evaluation, the CMS report will include a supplement to the site model to incorporate new monitoring data collected and information generated since that report was prepared. While the Update of Current Conditions presented an overall understanding of site conditions, the supplement will focus on those issues especially pertinent to the natural attenuation evaluation.

The natural attenuation evaluation process is described below. At a minimum, the evaluation will include the following tasks.

6.1 FIRST LINE OF EVIDENCE

The following activities will be performed to evaluate whether contaminant mass and/or concentrations are decreasing:

- **Comparison of contaminant isoconcentration maps over time.** Total chlorinated and total non-chlorinated VOC concentrations from sampling events completed in November 1991, December 1998/ January 1999 (the groundwater sampling event completed just prior to startup of the SVE system), and April 2000 will be compared to evaluate the location/extent of the plume in the Employee Parking Lot (i.e., whether the leading edge of the plume is growing, stable, or decreasing in size). In addition, concentrations of total chlorinated and total non-chlorinated VOCs in source area wells from the December 1998/January 1999 and May 2000 sampling events will be compared to evaluate the potential effects of the SVE system on groundwater quality.
- **Evaluation of contaminant concentrations in selected wells over distance and/or over time.** Monitoring wells MW-1 and MW-2 are located in the source areas for the chlorinated and non-chlorinated VOCs, well clusters MW-10 and MW-13 along the centerline of the primary plume, and the MW-23 cluster downgradient of the plume. Trends in VOC concentrations along the length of the plume, for which there are sufficient data, will be graphically represented by plotting a best fit line using regression. In addition, trend lines may be completed for individual wells within the plume by plotting concentrations of selected VOCs over time. Completion of trend lines for some VOCs may not be possible due to the potential of historically high detection limits masking the presence of compounds at lower concentrations.

Groundwater monitoring is presently scheduled to continue on an annual basis, at a minimum for the duration of operation of the SVE/VGR system. The ongoing monitoring results will be available to help verify ongoing contaminant degradation should natural attenuation be a component of the final remedy.

6.2 SECOND LINE OF EVIDENCE

Evaluation of the type(s) and rates of natural attenuation processes at the site and the rate at which such processes are occurring will include:

- **Completion of isoconcentration maps for geochemical indicators of natural attenuation.** Using data from the May 2000 groundwater sampling event, isoconcentration maps for electron acceptors (dissolved oxygen, nitrates, ferrous iron, manganese, sulfates, and oxidation-reduction potential, etc.) and metabolic byproducts (methane, ethane, ethene, and chloride) will be compared to isoconcentration maps for selected parent and daughter VOCs to provide an indication of what biodegradation processes are occurring. The isoconcentration maps for parent and daughter VOCs will include, but are not limited to TCE, 1,1,1,-TCA, cis-1,2-DCE, vinyl chloride, toluene, and xylenes.

- Estimation of biodegradation rates. Biodegradation rates will be calculated for VOCs within the plume, for which there is sufficient data, by plotting the logarithm of the VOC concentration over time and/or over distance. The biodegradation rates will be estimated from the slope of a best fit line using regression. Estimation of biodegradation rates for some VOCs may not be possible due to the potential of historically high detection limits masking the presence of some compounds at lower concentrations.

In addition to a presentation of the lines of evidence used to evaluate natural attenuation, the report will also include a discussion of the following topics:

- Site hydrogeologic conditions
- Site geochemistry
- Long-term and seasonal trends in groundwater flow conditions and plume behavior
- The effects of the mixture of chlorinated and non-chlorinated compounds on natural attenuation; aerobic and anaerobic zones; presumed biodegradation processes
- The effects of the SVE/VGR system on natural attenuation
- Estimated degradation rates and the capacity of the aquifer to sustain natural attenuation over time
- An evaluation of the suitability of the existing well network for monitoring attenuation processes

Groundwater monitoring is scheduled to be performed on an annual basis starting in 2000. The sampling plan for the natural attenuation evaluation as described in Section 6.0 will be performed during the year 2000 annual sampling event scheduled for May 2000.

The CMS Report will include a proposed schedule for continuation of long-term monitoring, or a proposal for terminating monitoring, as warranted by the final remedy selection.

8.1 PROJECT ORGANIZATION

This project will be organized and managed in a manner consistent with previous activities and interactions with EPA on the project. Respondents share joint responsibility for all submissions to EPA. Technical work will continue to be managed by Mr. Rick Meyer of United Technologies Corporation. EPA communication on technical matters related to the CMS should continue to be directed to Mr. Meyer at (860) 728-7596.

Mr. Meyer will direct the performance of the CMS. Technical consulting on the CMS will be provided jointly by URSGWC and Envirogen, with input provided by BTR and their technical consultant, Environmental Science & Engineering, Inc. (ESE). Mr. David Dods (URSGWC) and Mr. Patrick Woodhull (Envirogen) will act as the engineering project managers. Mr. Dods and Mr. Woodhull report directly to Mr. Meyer. Mr. Dennis Brinkley will act as project manager for ESE. A project organization chart is included as Figure 2. A brief description of the qualifications of project personnel is presented below.

Rick Meyer, Project Coordinator (UTC)

Mr. Meyer is an Environmental Project Engineer with 15 years experience in the environmental and hazardous waste field. He has worked on a number of RCRA and Superfund remediation projects during that period. Mr. Meyer has worked on the Keokuk Facility RCRA project since 1997.

David Dods, Project Manager (URSGWC)

Mr. Dods is an environmental engineer with 17 years of experience in the environmental and hazardous waste field. He has worked on RCRA projects throughout that period and has managed multiple engineering, remediation, and treatment projects. Mr. Dods has been the project manager for UTC's corrective action work at the Facility since project inception.

Jim Garrison, Ph.D., Toxicologist and Lead Risk Assessment Specialist (URSGWC)

Dr. Garrison is a toxicologist with 10 years of experience in risk assessment. Dr. Garrison is one of URSGWC's lead risk assessors, with expertise in both human heath and ecological risk assessment. While at URSGWC, Dr. Garrison has been the primary author on numerous risk-related documents, including baseline risk assessments, cleanup goals documents, ecological risk assessments, risk assessment work plans, and detailed toxicological profiles and has performed risk work in every EPA region, as well as internationally (Canada, Europe, and Australia)

Klaas Doeden, P.G., Hydrogeologist (URSGWC)

Mr. Doeden is a hydrogeologist with 9 years of experience in the environmental and hazardous waste field. He has acted as Assistant Project Manager, Site Manager, and Field Team Leader on a number of RCRA and Superfund investigation and remediation projects during that time, including several located in southeast Iowa. Mr. Doeden has worked on the Keokuk Facility RCRA Project since 1997.

John Moylan, Technical Advisor/Peer Reviewer (URSGWC)

Mr. Moylan has 41 years experience in engineering geology and the environmental and hazardous waste field. Prior to coming to URSGWC, Mr. Moylan served as Chief of both the Geology and Geotechnical Sections of the Kansas City District, U.S. Army Corps of Engineers. Mr. Moylan has 16 years experience in remedial design and has served as technical advisor and peer reviewer on a multiple remediation projects in the U.S. and overseas.

Patrick M. Woodhull, P.E. Project Manager/Principal Engineer (Envirogen)

Mr. Woodhull has worked with innovative biological technologies in the environmental remediation field since 1987. His professional background spans nearly every phase of remediation, including system design, laboratory-and pilot-scale testing, field construction, system operation and optimization, site closure, and project management. He has experience with a wide range of conventional and innovative remediation technologies, including bioventing, biosparging, dual-phase vacuum extraction, composting, soil vapor extraction, monitored natural attenuation for in situ applications.

Douglas G. Larson, Ph.D., Principal Engineer (Envirogen)

Dr. Larson has managed a broad range of environmental assessment and remediation projects. Dr. Larson has designed and managed the construction of remedial systems, and developed pilot test protocols for soil vapor extraction, air sparging, and multi-phase extraction systems. He has been the technical lead on projects involving bioremediation, contaminant fate and transport modeling, risk assessment, feasibility evaluation, laboratory equipment design, computer-automated control systems, and electronic instrumentation.

Mary F. DeFlaun, Ph.D. Director, Bioremediation Technologies (Envirogen)

Dr. DeFlaun is a highly experienced research director with a background in both academia and industry with over 15 years of related experience. As a microbiologist and a molecular geneticist, she has worked extensively in the areas of microbial adhesion and microbial transport. She has particular expertise in the degradation of chlorinated organic compounds. As Director of Envirogen's Bioremediation Technologies Program, Dr. DeFlaun develops and implements R&D programs related to the optimization of in situ hazardous waste treatment processes. Her current responsibilities include field demonstration and commercialization of bioremediation processes.

Dennis Brinkley, P.E., P.G., Environmental Science and Engineering, Inc.

Mr. Brinkley is a geological engineer with 11 years of experience conducting geologic and hydrogeologic investigations, characterizations, and corrective actions. He has worked on a number of RCRA and Superfund investigation and remediation projects during that period. Mr. Brinkley has worked on environmental investigations at the 3200 Main Street Facility since 1990.

8.2 PROJECT SCHEDULE AND REPORTING

The Respondents will provide EPA with the following CMS deliverables according to the schedule below:

Deliverables	Due Date
Exposure Pathway Analysis for cleanup standards (Technical Memo #1)	90 days after EPA approval of the CMS Work Plan
Identification of Risk Equations and Transport Models, plus Screening of Technologies and Development of Corrective Measures Alternatives (Technical Memo #2)	60 days after approval of Technical Memo #1
Media Cleanup Standards (Technical Memo #3)	60 days after approval of Technical Memo #2
Draft CMS Report	60 days after approval of Technical Memo #3
Final CMS Report	45 days after receipt of EPA comments on the draft CMS Report

Figure 3 presents a timeline schedule based on the submittal dates presented above. Table 2 presents a preliminary outline for the CMS Report. The approval date for the CMS Work Plan and the time required for EPA review of submittals have been estimated to allow for completion of the timeline schedule. In addition, ongoing project activities such as groundwater sampling and operation of the SVE system have been included on a separate timeline on the schedule.

ASTM. 1998. Standard Guide for Remediations of Groundwater by Natural Attenuation at Petroleum Release Sites.

Envirogen. January 30, 1998. Interim Measures Remediation Work Plan: Soil Vapor Extraction System Design.

Envirogen. May 1999. SVE Construction and Startup Report.

EPA. 1989. Risk Assessment Guidances for Superfund. Volume 1. Human Health Evaluation Manual.

EPA. May 1994. RCRA Corrective Action Plan.

EPA. 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater.

EPA. July 1999. RCRA Cleanup Reforms.

MWR. April 1, 1993. Soil Vapor Extraction Pilot Study.

URSGWC. 1999. Update of Current Conditions, Facility at 3200 Main Street, Keokuk, Iowa.

Woodward-Clyde Consultants. December 1991. Pre-Investigation Evaluation of Corrective Measures Technologies.

Tables

TABLE 1

METHODS OF ANALYSIS, HOLDING TIMES, AND SAMPLE CONTAINERS AND PRESERVATIVES FOR NATURAL ATTENUATION GROUNDWATER SAMPLES

MONITORING PARAMETER	METHOD OF ANALYSIS[1,2]	HOLDING TIME	SAMPLE CONTAINER AND PRESERVATIVE[3]
Volatile Organic Constituents	EPA Method 8260B	14 Days	3 – 40-mL volatile organic analysis (VOA) vials with HCL to pH < 2
Volatile Fatty Acids			
Methane, Ethane, Ethene, Propane, Propene	Robert S. Kerr (RSK) 175	14 Days	3 – 50-mL glass serum bottles with gray butyl/teflon-faced septa and crimp top
Total Organic Carbon (TOC)	SW-846 Method 9060	28 Days	500-mL amber glass bottle with H_2SO_4 to pH < 2
Arsenic	EPA Method 6010B (trace ICP)	6 Months	100-mL plastic bottle with HNO_3 to pH < 2
Iron (II) (Fe^{+2})	Hach Field Test Kit[1]	---	---
Manganese	EPA Method 6010B (trace ICP)	6 Months	100-mL plastic bottle with HNO_3 to pH < 2
Calcium/Potassium/Sodium	EPA Method 6010B (trace ICP)	6 Months	100-mL plastic bottle with HNO_3 to pH < 2
Chloride	EPA Method 300.0	28 Days	250-mL glass bottle
Nitrate	EPA Method 300.0	14 Days	250-mL plastic bottle with H_2SO_4
Sulfate	EPA Method 300.0	28 Days	250-mL plastic bottle
Sulfide	Hach Field Test Kit[1]		
Alkalinity	EPA Method 310.1	14 Days	250-mL plastic bottle
Biochemical Oxygen Demand (BOD)	EPA Method 405.1	48 Hours	1-L plastic bottle
pH/Temperature/Conductivity	Field Measurement	---	---
Dissolved Oxygen	Field Measurement [4]	---	---
Oxidation-Reduction Potential	Field Measurement	---	---

Notes:
1 Or equivalent.
2 EPA accepted field monitoring techniques for lab samples may be substituted where applicable.
3 All samples preserved @ 4°C.
4 Dissolved oxygen will be measured using both flow-through and in-situ meters if the well diameter permits

TABLE 2

Preliminary CMS Report Outline
Facility at 3200 Main
Keokuk, Iowa

Section 1.0 Introduction
- 1.1 Purpose of the CMS Report
- 1.2 CMS Report Organization

Section 2.0 Summary Review of Current Conditions
- 2.1 Facility History and Layout
- 2.2 Contaminant Source Areas
- 2.3 Degree and Extent of Contamination

Section 3.0 Summary Review of Agreed Media Cleanup Standards

Section 4.0 Corrective Action Objectives

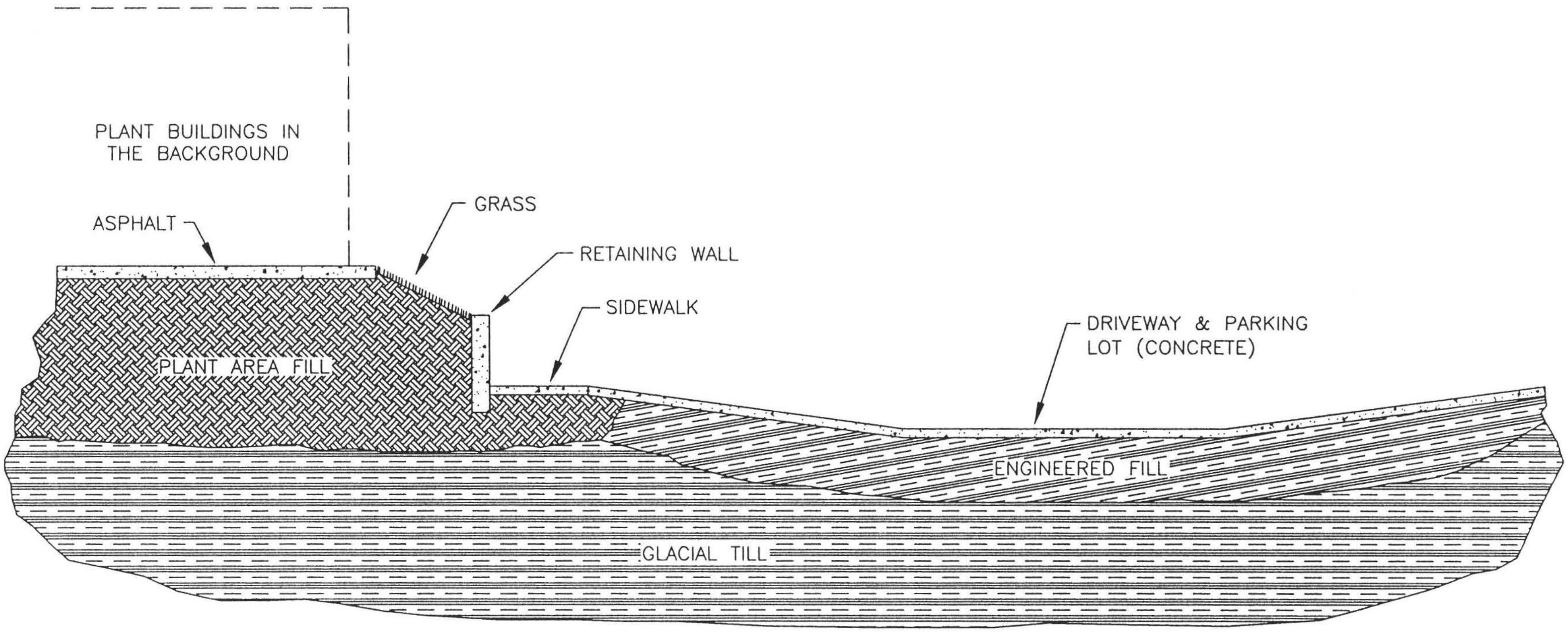
Section 5.0 Summary Review of Preliminary Screening of Technologies and Development of Corrective Measure Alternatives
- 5.1 Preliminary Screening of Technologies
- 5.2 Development of Corrective Measure Alternatives

Section 6.0 Detailed Evaluation of Corrective Measure Alternatives
- 6.1 Evaluation Criteria
- 6.2 Evaluation of Alternative 1
- 6.3 Evaluation of Alternative 2
- 6.4 Evaluation of Alternative 3 (as needed)

Section 7.0 Recommendation and Justification of a Corrective Measure for the Site
- 7.1 Recommended Alternative
- 7.2 Justification of the Recommended Alternative

Section 8.0 Summary and Conclusions

Section 9.0 References



SCALE	NO SCALE
PROJECT MGR.	J. WHITNEY
DRAWN	TRY
DWG NAME	contamination zones
PROJECT NO.	55005
DATE	11-29-99

PLOT SCALE: 1 January 14, 2000 12:34:06 pm (RAD)
J:\91c7343-6\contamination zones.dwg

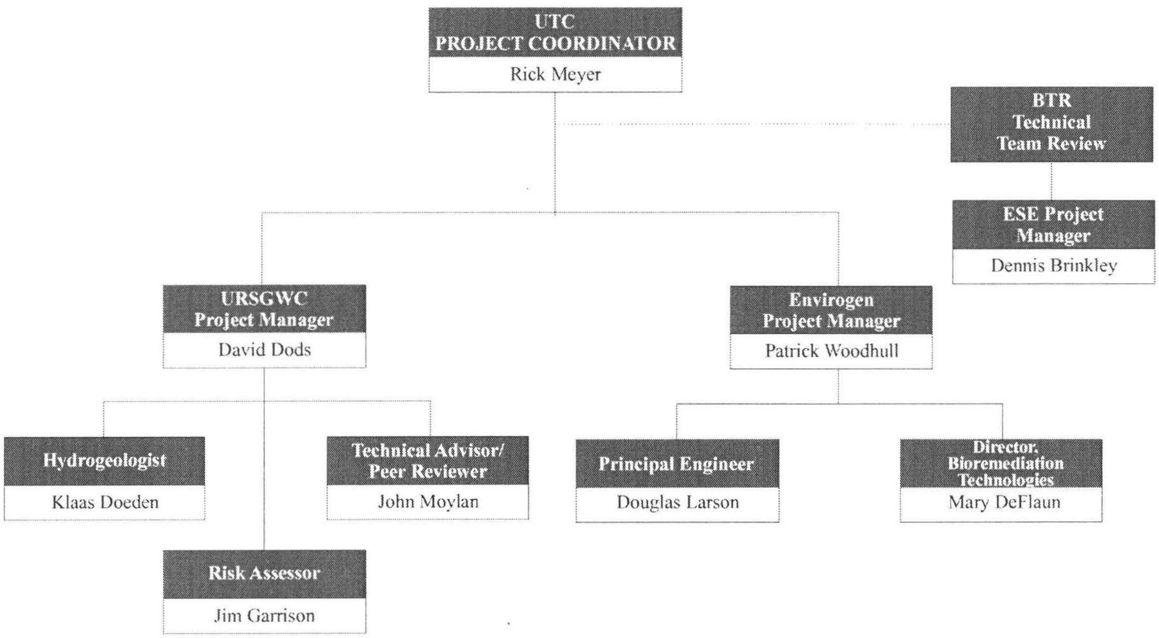
ENVIROGEN
INNOVATIVE SOLUTIONS FOR ENVIRONMENTAL PROBLEMS
5126 WEST GRAND RIVER AVENUE
LANSING, MICHIGAN 48906

KEOKUK SITE
KEOKUK, IOWA

CROSS-SECTION SCHEMATIC SHOWING
3 ZONES OF SOIL CONTAMINATION

FIGURE NO. 1

FIGURE 2
PROJECT ORGANIZATION CHART



The CMS will include two major series of tasks. The first is the development of media cleanup standards for the Facility. The second is the evaluation of corrective measures technologies and alternatives. These two series of work activities are closely related. Although the evaluation of corrective measures technologies can be initiated concurrent with the development of cleanup standards, the detailed evaluation of alternatives can not be completed until after the cleanup standards are finalized. In addition, the schedule for completing the evaluation of alternatives is dependent on the schedule for conducting further groundwater monitoring to evaluate natural attenuation. Finally, it is also advantageous to complete at least the first year of operation of the existing Soil Vapor Extraction/Vacuum Groundwater Recovery (SVE/VGR) system prior to completing the evaluation. The interrelationship of these tasks is discussed further in the subsequent sections describing each task.

The process for developing media cleanup standards has been proposed in three steps, each to be reported through submittal of a technical memorandum:

1. Exposure pathway analysis
2. Identification of risk equations and transport models
3. Calculation of cleanup goals

These steps are further described in Section 3.

The technical evaluation of corrective measures will be performed in two steps:

1. Identification, Screening, and Development of Corrective Measures Alternatives
2. Evaluation of Corrective Measures Alternatives

The first step will be initiated concurrent with the development of the media cleanup standards and is described in Section 4. The second step will be completed after finalization of the cleanup standards. This step is described in Section 5.

The EPA is in the process of implementing a set of administrative reforms known as the RCRA Cleanup Reforms with the intent of achieving faster, more efficient cleanups at RCRA corrective action sites (EPA, July, 1999). To this goal, this work plan proposes a focused CMS. The focused approach is applicable at the Facility given the limited area of contamination, the large amount of characterization data that has been collected for the size of the site, and the valuable performance data that is currently being generated through the operation of the existing SVE/VGR remediation system. The focused CMS is also consistent with EPA guidance (RCRA Corrective Action Plan, May 1994) that states, "The scope and requirements of the CMS . . . need to be balanced with the expeditious initiation of remedies and rapid restoration of contaminated media..."

EPA's RCRA Cleanup Reforms identify two environmental indicators as key measures of progress towards meeting reform goals. These are "Current Human Exposures under Control" and "Migration of Contaminated Groundwater under Control." In order to aid EPA in assessing progress toward meeting cleanup reform goals for the Facility, these two key indicators will be addressed in both the cleanup standards and CMS deliverables produced by this project.

Cleanup goals for the Facility will be developed using a risk-based approach that takes into account a number of site-specific factors, such as land use, potentially exposed populations, lack of a potable aquifer, etc. This type of information, which is commonly developed as part of a Baseline Risk Assessment, is used to identify the populations, media, and chemicals of concern. Risk-based cleanup goals are subsequently developed for only those chemicals and media of concern that have been identified as posing a potentially unacceptable risk to any exposed populations

Because a Baseline Risk Assessment has not been performed, site-specific information required to calculate cleanup goals will be developed in a series of three technical memoranda (TM), as identified below:

The first TM will provide an exposure pathway analysis for contaminated media, using standard EPA protocols. The purpose of this first cleanup goal submittal is to come to agreement with EPA about the chemicals and media that require cleanup, and the receptor(s) (human and environmental) that the cleanup goals are designed to protect.

An exposure pathway refers to the mechanism by which a receptor may come in contact with a chemical. As defined by EPA risk guidance (1989), there are four major elements that characterize a complete exposure pathway. These elements are:

- A source and mechanism of chemical release
- A transport medium for the chemical
- A point of potential receptor contact with the medium (e.g. exposure point)
- A route of exposure (e.g. ingestion) for the receptor to come into contact with the chemical

For an exposure pathway to be complete, all four elements must be present. The absence of any one of these elements results in an incomplete exposure pathway for which site-related health risks do not exist. Thus, the evaluation of potential exposure pathways is necessary to focus on only those pathways that have potential to impact receptors (i.e., cleanup goals need only be developed only for those contaminated media with complete exposure pathways).

The exposure pathway analysis presented in TM # 1 will be performed using a site conceptual exposure model (SCEM) to help identify potentially complete/significant pathways. The SCEM specifically addresses each of the four components of an exposure pathway. In addition to the SCEM, the following site-specific information will be provided in the TM:

- Chemicals of Concern (COCs) and the methodology used for their selection
- A discussion of current and likely future land and groundwater use at the site and in the surrounding community
- A qualitative discussion of the nature and extent of contaminated media, as it relates to potential human exposure
- Identification of receptor populations that could reasonably be expected to come into contact with site-related contaminants

This evaluation will be used to identify the COCs, the media that require cleanup, the receptor population(s) that the cleanup goals are targeted to protect, and the scenarios that will be used to develop the cleanup goals.

The purpose of TM # 2 is to come to agreement with EPA for the technical approach to be used to calculate cleanup goals. Risk-based cleanup goals can be developed using a number of different equations/models. The choice of the most appropriate models and exposure equations to use in the cleanup goal calculations is dependent on the scenario/population being evaluated and the media that require cleanup. The purpose of TM # 1 is to identify these scenarios/populations/media. Upon approval of TM # 1, a second TM (TM # 2) will be submitted that identifies the specific risk equations and transport models that will be used in the cleanup goal calculations. This will include a description of all major proposed target risk levels, input assumptions, and exposure factors that will be used to calculate the site-specific cleanup goals.

Upon approval of TM # 2, health-protective cleanup goals will be calculated for Facility contaminants and submitted in TM # 3. This TM will incorporate the information provided in the first two TMs so as to provide complete documentation in one source document.

4.1 KEY SITE CHARACTERISTICS

The following sections present a summary of the key site characteristics pertinent to the evaluation of corrective measures as identified during investigation activities. A detailed discussion is presented in the September 1999 Update of Current Conditions Report prepared by URS Greiner Woodward Clyde (URSGWC) and previously submitted to EPA.

Source Areas and Contaminants of Concern

Previous investigations at the Facility have detected the presence of VOCs in soil and groundwater in the general area around the Chemical Mixing Building. The primary source of soil and groundwater contamination was the five underground solvent product tanks formerly located adjacent to the east side of the Chemical Mixing Building. The five tanks were removed in 1989. In addition to the USTs, there were several additional potential source areas identified which included leakage from an underground pipeline connecting the solvent product tanks to the main facility, leakage from a former underground gasoline tank, and the drum storage area. An additional source of limited soil and groundwater VOC contamination is present in the vicinity of MW-20. However, the concentrations in that area are significantly lower than in the vicinity of the former underground tanks.

Investigations in the area surrounding the source areas identified the following chlorinated and non-chlorinated compounds for the Facility: toluene, hexane, methyl ethyl ketone (MEK), methylene chloride, trichloroethene (TCE), 1,1,1-trichloroethane (TCA), butanol, ethanol, acetone, benzene, carbon disulfide, carbon tetrachloride, chloroethane, 1,1-dichloroethane (DCA), 1,2-DCA, 1,1-dichloroethene (DCE), 1,2-DCE, ethyl benzene, 4-methyl-2-pentanone (MIBK), 1,1,2,2-tetrachloroethane, tetrachloroethene (PCE), 1,1,2-TCE, vinyl chloride, and xylenes.

Key Topographic, Geologic, and Hydrogeologic Features

Facility topography plays an important role in limiting the migration of contaminants. The original topography in the investigation area has been substantially modified over the years to accommodate development of the Facility. A general cross-section was developed to represent the distinct features produced with the modifications (Figure 1).

The topography and the geologic units at the Facility are discussed in detail in the September 1999 Update of Current Conditions Report. In general, the ground surface in the investigation area has a topographic high in the area directly between the southwest side of the Facility and the Chemical Mixing Building. This topographic high was artificially produced with fill material referred to as "Plant Area Fill." To the south and west of the Chemical Mixing Building, the Plant Area Fill material rapidly slopes down to the edge of the Employee Parking Lot where the Plant Area Fill material ends. Topography in the Employee Parking Lot area is formed from an Engineered Fill material, which was installed so that it gently slopes toward a natural topographic low in the center of the Employee Parking Lot.

The fill materials from the two areas have different characteristics. The Plant Area Fill was placed to increase the area available for plant expansion. The source of the Plant Area Fill is not known and the material and degree of compaction appears variable. The Plant Area Fill generally consists of firm to stiff, olive-brown to dark brown, medium plastic, silty clay with varying amounts of sand, gravel, brick, rubber and debris. The Engineered Fill material appears to be glacial till that was moved to fill the former northwest trending drainage for construction of the Employee Parking Lot. The degree of compaction appears greater and more consistent than the plant area fill. The engineered fill generally consists of soft to firm, yellowish-brown to olive-brown with some gray mottling, low plastic, silty clay with some sand and gravel.

The two fill material areas are underlain by a native glacial till. The glacial till consists of an oxidized and weathered upper till zone underlain by a dense unoxidized and unweathered till zone. The uppermost glacial till zone generally consists of oxidized, firm to stiff, yellowish-brown to light brown with gray mottling, medium to highly plastic clay with iron-oxide staining, vertical fractures and fine to medium sands with a trace of fine gravel. Fractures were typically encountered to approximately 30 feet below ground surface (bgs). Many fracture surfaces at shallow depths in the oxidized till were iron stained. The upper till zone contains discontinuous silty sand lenses which range typically from several inches to several feet thick. The sand lenses tend to be isolated, discontinuous, and lenticular, with a high percentage of fines. At approximately 30-35 feet bgs, the glacial till transitions from being oxidized and weathered to unoxidized and unweathered. In this transition zone, the density increases significantly and the color begins to change to where the lower unoxidized glacial till becomes very stiff to hard, dark gray with almost no fractures.

Contaminant Migration and Containment On-Site

The primary plume consisting of chlorinated and non-chlorinated VOCs has migrated approximately 160 feet away from the former underground solvent product tanks area and the Old Hazardous Waste Storage Area to the Employee Parking Lot. Chemical data plus groundwater elevation contours indicate that the plume is not moving off-site. A secondary plume, consisting primarily of non-chlorinated VOCs at much lower concentrations, has not moved a great distance from the source area near MW-20. The secondary plume is very localized and recent data indicates that concentrations are declining in that area and are below MCLs.

The glacial tills are composed primarily of clays. Investigation and monitoring data have shown the soils to be "tight" and yield small amounts of water. Monitoring wells typically can be drawn down or completely dewatered at very low flow rates.

Site Physical Features

The contaminated area of the property is industrialized and is located in a very active portion of the Facility. Multiple facility structures are present in the area: the main plant building, the Chemical Mix building, an above-ground storage tank, fences, gates, sidewalks, etc. Overhead and buried utilities are present at the Facility. The area receives heavy vehicle traffic. Trucks and railcars enter the Facility, load, and unload in the area. South 31st Street and the Employee Parking Lot receive frequent vehicle traffic and workers enter the Facility along a sidewalk and plant entrance that are located in the area of concern. Finally, the majority of the area is paved to support the truck traffic and worker vehicles. All of these factors will need to be considered when evaluating corrective measures for the Facility.

4.2 CORRECTIVE MEASURES TECHNOLOGIES TO BE REVIEWED

4.2.1 Review of the Pre-Investigation Evaluation of Corrective Measures Technologies Report

In December 1991, Woodward-Clyde prepared a Pre-Investigation Evaluation of Corrective Measures Technologies Report (PECMTR) for the Facility. The purpose of the report was to identify potential corrective measures technologies that may be used for the containment, treatment, remediation, and/or disposal of potential contaminated media which may be present at the Facility. Eleven potential corrective measures technologies for soils and/or groundwater were identified for consideration:

1. No Action (Soil and Groundwater)
2. Institutional Controls (Soil and Groundwater)
3. Capping Methods (Soil)
4. Bioreclamation (Soil)
5. Excavate and Remove to Off-Site Location (Soil)
6. Excavate and Consolidate into a landfill or waste management area on-site (Soil)
7. Soil Vapor Extraction (Soil)
8. Soil Washing (Soil)
9. Thermal Treatment Methods (Soil)
10. Other Physical In-situ Methods (Soil)
11. Hydraulic Control of Groundwater Movement including passive recovery systems, containment systems, and active recovery systems (Groundwater).

This list of technologies was prepared prior to conducting the RFI and was based on possible contaminants that might be encountered based on what was known of the site at that time. For example, metals, semi-volatile organics, and oils were considered possible contaminants at that time, and are no longer a concern for the CMS. As such, many of these technologies are no longer applicable. As described later, a refined list of technologies has been developed for consideration during the CMS. The following technologies identified in the PECMTR will be carried forward into the CMS process and supplemented by additional technologies:

- No action
- Institutional controls
- Soil vapor extraction

4.2.2 Soil Vapor Extraction System Pilot Study and Interim Measures Implementation

Envirogen conducted a SVE pilot study at the Site in May 1992. Methodology and results of the pilot study are documented in the report, Soil Vapor Extraction Pilot Study (April 1, 1993). Envirogen determined SVE to be a feasible remedial technology for the Facility as a result of

2. Institutional Controls
3. Continue operation of existing SVE/VGR system
4. Expansion of the existing SVE/VGR system
5. Natural attenuation
6. Enhanced in-situ biodegradation

A brief description of each of the technologies is presented below.

1. No Action. This technology consists of the site remaining "as-is" and no provisions are made for the implementation of monitoring activities or remediation technologies of the contaminated media. This option would be applicable to sites if the risk to human health and the environment are assessed as acceptable based on applicable regulatory guidelines. Considerations during the assessment would include potential receptors and exposure pathways for the contaminated media at the site.
2. Institutional Controls. Institutional controls involve the creation and implementation of responsibilities for regulating and limiting human and environmental contact with the media and contaminants. This technology may include physical restrictions such as limiting site access by a security fence, zoning or deed restrictions on future site activities to limit exposure to the contaminants, and restrictions on site construction activities. This alternative typically includes a sampling program to monitor the long-term potential migration of contaminants and the effectiveness of the institutional controls to prevent exposure to potential receptors.
3. Continued Operation of the Existing SVE/VGR System. A soil vapor extraction (SVE) and vacuum groundwater recovery (VGR) system was installed in the former underground solvent product tanks area beginning in October 1998. The purpose of the SVE/VGR system is to remove compounds from the source area soils and minimize impact to groundwater through volatilization and recovery of the target compounds. This system is described in further detail in Section 4.2.2. This technology will evaluate the continued operation of the SVE/VGR system to meet the CMS objectives.
4. Expansion of the Existing SVE/VGR System. This technology will evaluate the expansion of the current SVE/VGR system. System expansion may include the installation of additional vacuum, injection, or VGR wells, modification of current extraction and injection flowrates, or modifications to system operating parameters (i.e., pulsed sparging cycles).
5. Natural Attenuation. Natural attenuation (also known as intrinsic remediation) of compounds in groundwater results from the integration of several subsurface attenuation mechanisms, both destructive and nondestructive. These processes include biodegradation, dispersion, sorption, volatilization, and dilution via infiltration. The objective of this process is to document that natural processes occurring at the site will reduce the concentrations of the target contaminants to below regulatory standards before potential receptor exposure pathways are completed.
6. Enhanced In Situ Biodegradation. The chlorinated and non-chlorinated compounds identified at the Facility are susceptible to biological degradation to a varying extent. This technology will evaluate the effect of possible modifications or supplements to the SVE/VGR system,

such as nutrient addition, bioaugmentation, and co-substrate addition to enhance biological degradation and meet CMS objectives.

4.3 TECHNOLOGY SCREENING PROCESS AND DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

4.3.1 Technology Screening Process

The technologies identified in Section 4.2.3 will be screened to eliminate those that may prove infeasible to implement, that rely on technologies unlikely to perform satisfactorily or reliably, or do not achieve the Facility cleanup goals within a reasonable period. This screening process will focus on eliminating the technologies that have severe limitations for the Facility's waste and site specific conditions. The screening step will also eliminate any technologies that have inherent technology limitations.

The following site, waste, and technology characteristics will be used to screen out inapplicable technologies:

Site Characteristics

Site data collected during the facility investigations and operation of the SVE/VGR remediation system will be reviewed to identify conditions that may limit or promote the selection of certain technologies. For example, a key consideration at this site is the soil type, the clay glacial tills. The till formation is tight and yields little water during pumping of existing monitoring wells. All technologies that are not applicable to site conditions will be eliminated from further consideration.

Waste Characteristics

Identification of contaminant characteristics that limit the effectiveness or feasibility of the technologies is an important criteria during the screening process. All technologies that are clearly limited or inappropriate for the Facility contaminant characteristics will be eliminated from further consideration.

Technology Limitations

During the screening process, the level of technology development and commercialization stage, performance record, and inherent installation, operation, and maintenance issues will be identified for each technology considered. Technologies that are not ready for field implementation, are considered unreliable or unpredictable, or are poor performers may be eliminated from further consideration. However, innovative treatment technologies (such as technologies other than pumping with conventional treatment for groundwater) will be considered for the site. Innovative treatment technologies (i.e., soil vapor extraction, bioremediation, monitored natural attenuation) may require additional efforts to gather data, analyze options, and implement the technology at the Facility. However, the current SVE system will provide a large volume of site-specific operating and performance data.

4.3.2 Development of Corrective Measure Alternatives

After completion of the screening process, the technologies most suitable for the site will be retained for detailed analysis. The retained technologies will be used to form one or more corrective measures alternatives. Each alternative may consist of a single technology or a combination of technologies.

The results of the screening process, the description of the alternative or alternatives retained for detailed analysis, and the reasons for excluding technologies from further analysis will be presented concurrent with the Cleanup Goals Technical Memorandum #2.

- **Implementability.** Implementability is often the determining factor in selection of a remedy. The implementability of each alternative will be assessed based on administrative activities required (i.e., permits, off-site approvals, etc.) and the time associated with the administrative activities; the constructability, implementation timeline, and the time to achieve beneficial results; the availability of the required technical resources and materials; and the availability of the prospective technologies for each alternative.
- **Cost.** The relative cost of a technology will be considered, especially if several different technical approaches offer equivalent protection of human health and the environment but vary in cost. A relative cost estimate will be prepared for each corrective measure alternative and will include the costs for tasks such as engineering, site preparation, construction, implementation, operation and maintenance, sampling, analytical, and permitting activities.

A final Corrective Measure Alternative will be recommended using the criteria set forth above. The recommended alternative will be presented in the CMS Report. The report will contain a detailed description of the evaluation process described in this section and the rationale for the recommendation. The report will include summary tables for each alternative which highlight the tradeoffs between protection of human health and environment, the ability to attain cleanup goals, long- and short-term effectiveness, implementability, cost, and other pertinent factors.

The Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, (EPA, 1998) and the Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites (ASTM, 1998) identify three lines of evidence that may be used to evaluate whether natural attenuation of chlorinated and non-chlorinated VOCs is a viable corrective measure option. The three lines of evidence are:

- **First Line of Evidence** - Historical soil or groundwater data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentrations over time at appropriate monitoring or sampling points;
- **Second Line of Evidence** - Hydrogeologic or geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels;
- **Third Line of Evidence** - Data from field or microcosm studies (conducted in or with actual contaminated site media) which directly demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern.

The EPA Technical Protocol states that unless EPA or the implementing state agency determines that the data supporting the first line of evidence are of sufficient quality and duration to support selection of natural attenuation as a corrective measure, data supporting the second line of evidence will also be required. Where data supporting the second line of evidence is inadequate or inconclusive, data supporting the third line of evidence may also be necessary.

A preliminary evaluation of data supporting the first two lines of evidence was presented in the Update of Current Conditions, Facility at 3200 Main Street, Keokuk, Iowa, (URSGWC, 1999). The preliminary evaluation consisted of evaluating contaminant concentrations over time in a number of wells (first line of evidence) plus geochemical indicators of natural attenuation (second line of evidence). Results of the evaluation indicated that concentrations of a number of VOCs have decreased over time. In addition, a number of geochemical indicators suggested that natural attenuation is occurring. Based on these results, further evaluation of natural attenuation in the CMS was recommended.

Natural attenuation will be further evaluated in the CMS by a more rigorous evaluation of the first and second lines of evidence. The third line of evidence will not be evaluated. Data collection activities to support these two lines of evidence include additional groundwater sampling to evaluate concentrations and distribution of VOCs and geochemical indicators of natural attenuation including parent and daughter compounds, electron acceptors, and metabolic byproducts. Specific analytical parameters are included in Table 1. Groundwater samples to be analyzed for these parameters are scheduled to be collected in May 2000. The preliminary natural attenuation evaluation was performed on data collected prior to the startup of the SVE/VGR system. The May 2000 sampling event is scheduled after the system has operated for a year. Evaluation of the first and second lines of evidence, will be based on data from the May 2000 sampling event as well as historical data.

The Update of Current Conditions Report prepared in September 1999 was essentially a conceptual site model. Recognizing that the conceptual site model is an important component of a natural attenuation evaluation, the CMS report will include a supplement to the site model to incorporate new monitoring data collected and information generated since that report was prepared. While the Update of Current Conditions presented an overall understanding of site conditions, the supplement will focus on those issues especially pertinent to the natural attenuation evaluation.

The natural attenuation evaluation process is described below. At a minimum, the evaluation will include the following tasks.

6.1 FIRST LINE OF EVIDENCE

The following activities will be performed to evaluate whether contaminant mass and/or concentrations are decreasing:

- Comparison of contaminant isoconcentration maps over time. Total chlorinated and total non-chlorinated VOC concentrations from sampling events completed in November 1991, December 1998/ January 1999 (the groundwater sampling event completed just prior to startup of the SVE system), and April 2000 will be compared to evaluate the location/extent of the plume in the Employee Parking Lot (i.e., whether the leading edge of the plume is growing, stable, or decreasing in size). In addition, concentrations of total chlorinated and total non-chlorinated VOCs in source area wells from the December 1998/January 1999 and May 2000 sampling events will be compared to evaluate the potential effects of the SVE system on groundwater quality.
- Evaluation of contaminant concentrations in selected wells over distance and/or over time. Monitoring wells MW-1 and MW-2 are located in the source areas for the chlorinated and non-chlorinated VOCs, well clusters MW-10 and MW-13 along the centerline of the primary plume, and the MW-23 cluster downgradient of the plume. Trends in VOC concentrations along the length of the plume, for which there are sufficient data, will be graphically represented by plotting a best fit line using regression. In addition, trend lines may be completed for individual wells within the plume by plotting concentrations of selected VOCs over time. Completion of trend lines for some VOCs may not be possible due to the potential of historically high detection limits masking the presence of compounds at lower concentrations.

Groundwater monitoring is presently scheduled to continue on an annual basis, at a minimum for the duration of operation of the SVE/VGR system. The ongoing monitoring results will be available to help verify ongoing contaminant degradation should natural attenuation be a component of the final remedy.

6.2 SECOND LINE OF EVIDENCE

Evaluation of the type(s) and rates of natural attenuation processes at the site and the rate at which such processes are occurring will include:

- Completion of isoconcentration maps for geochemical indicators of natural attenuation. Using data from the May 2000 groundwater sampling event, isoconcentration maps for electron acceptors (dissolved oxygen, nitrates, ferrous iron, manganese, sulfates, and oxidation-reduction potential, etc.) and metabolic byproducts (methane, ethane, ethene, and chloride) will be compared to isoconcentration maps for selected parent and daughter VOCs to provide an indication of what biodegradation processes are occurring. The isoconcentration maps for parent and daughter VOCs will include, but are not limited to TCE, 1,1,1,-TCA, cis-1,2-DCE, vinyl chloride, toluene, and xylenes.

- Estimation of biodegradation rates. Biodegradation rates will be calculated for VOCs within the plume, for which there is sufficient data, by plotting the logarithm of the VOC concentration over time and/or over distance. The biodegradation rates will be estimated from the slope of a best fit line using regression. Estimation of biodegradation rates for some VOCs may not be possible due to the potential of historically high detection limits masking the presence of some compounds at lower concentrations.

In addition to a presentation of the lines of evidence used to evaluate natural attenuation, the report will also include a discussion of the following topics:

- Site hydrogeologic conditions
- Site geochemistry
- Long-term and seasonal trends in groundwater flow conditions and plume behavior
- The effects of the mixture of chlorinated and non-chlorinated compounds on natural attenuation; aerobic and anaerobic zones; presumed biodegradation processes
- The effects of the SVE/VGR system on natural attenuation
- Estimated degradation rates and the capacity of the aquifer to sustain natural attenuation over time
- An evaluation of the suitability of the existing well network for monitoring attenuation processes

Groundwater monitoring is scheduled to be performed on an annual basis starting in 2000. The sampling plan for the natural attenuation evaluation as described in Section 6.0 will be performed during the year 2000 annual sampling event scheduled for May 2000.

The CMS Report will include a proposed schedule for continuation of long-term monitoring, or a proposal for terminating monitoring, as warranted by the final remedy selection.

8.1 PROJECT ORGANIZATION

This project will be organized and managed in a manner consistent with previous activities and interactions with EPA on the project. Respondents share joint responsibility for all submissions to EPA. Technical work will continue to be managed by Mr. Rick Meyer of United Technologies Corporation. EPA communication on technical matters related to the CMS should continue to be directed to Mr. Meyer at (860) 728-7596.

Mr. Meyer will direct the performance of the CMS. Technical consulting on the CMS will be provided jointly by URSGWC and Envirogen, with input provided by BTR and their technical consultant, Environmental Science & Engineering, Inc. (ESE). Mr. David Dods (URSGWC) and Mr. Patrick Woodhull (Envirogen) will act as the engineering project managers. Mr. Dods and Mr. Woodhull report directly to Mr. Meyer. Mr. Dennis Brinkley will act as project manager for ESE. A project organization chart is included as Figure 2. A brief description of the qualifications of project personnel is presented below.

Rick Meyer, Project Coordinator (UTC)

Mr. Meyer is an Environmental Project Engineer with 15 years experience in the environmental and hazardous waste field. He has worked on a number of RCRA and Superfund remediation projects during that period. Mr. Meyer has worked on the Keokuk Facility RCRA project since 1997.

David Dods, Project Manager (URSGWC)

Mr. Dods is an environmental engineer with 17 years of experience in the environmental and hazardous waste field. He has worked on RCRA projects throughout that period and has managed multiple engineering, remediation, and treatment projects. Mr. Dods has been the project manager for UTC's corrective action work at the Facility since project inception.

Jim Garrison, Ph.D., Toxicologist and Lead Risk Assessment Specialist (URSGWC)

Dr. Garrison is a toxicologist with 10 years of experience in risk assessment. Dr. Garrison is one of URSGWC's lead risk assessors, with expertise in both human heath and ecological risk assessment. While at URSGWC, Dr. Garrison has been the primary author on numerous risk-related documents, including baseline risk assessments, cleanup goals documents, ecological risk assessments, risk assessment work plans, and detailed toxicological profiles and has performed risk work in every EPA region, as well as internationally (Canada, Europe, and Australia)

Klaas Doeden, P.G., Hydrogeologist (URSGWC)

Mr. Doeden is a hydrogeologist with 9 years of experience in the environmental and hazardous waste field. He has acted as Assistant Project Manager, Site Manager, and Field Team Leader on a number of RCRA and Superfund investigation and remediation projects during that time, including several located in southeast Iowa. Mr. Doeden has worked on the Keokuk Facility RCRA Project since 1997.

John Moylan, Technical Advisor/Peer Reviewer (URSGWC)

Mr. Moylan has 41 years experience in engineering geology and the environmental and hazardous waste field. Prior to coming to URSGWC, Mr. Moylan served as Chief of both the Geology and Geotechnical Sections of the Kansas City District, U.S. Army Corps of Engineers. Mr. Moylan has 16 years experience in remedial design and has served as technical advisor and peer reviewer on a multiple remediation projects in the U.S. and overseas.

Patrick M. Woodhull, P.E. Project Manager/Principal Engineer (Envirogen)

Mr. Woodhull has worked with innovative biological technologies in the environmental remediation field since 1987. His professional background spans nearly every phase of remediation, including system design, laboratory-and pilot-scale testing, field construction, system operation and optimization, site closure, and project management. He has experience with a wide range of conventional and innovative remediation technologies, including bioventing, biosparging, dual-phase vacuum extraction, composting, soil vapor extraction, monitored natural attenuation for in situ applications.

Douglas G. Larson, Ph.D., Principal Engineer (Envirogen)

Dr. Larson has managed a broad range of environmental assessment and remediation projects. Dr. Larson has designed and managed the construction of remedial systems, and developed pilot test protocols for soil vapor extraction, air sparging, and multi-phase extraction systems. He has been the technical lead on projects involving bioremediation, contaminant fate and transport modeling, risk assessment, feasibility evaluation, laboratory equipment design, computer-automated control systems, and electronic instrumentation.

Mary F. DeFlaun, Ph.D. Director, Bioremediation Technologies (Envirogen)

Dr. DeFlaun is a highly experienced research director with a background in both academia and industry with over 15 years of related experience. As a microbiologist and a molecular geneticist, she has worked extensively in the areas of microbial adhesion and microbial transport. She has particular expertise in the degradation of chlorinated organic compounds. As Director of Envirogen's Bioremediation Technologies Program, Dr. DeFlaun develops and implements R&D programs related to the optimization of in situ hazardous waste treatment processes. Her current responsibilities include field demonstration and commercialization of bioremediation processes.

Dennis Brinkley, P.E., P.G., Environmental Science and Engineering, Inc.

Mr. Brinkley is a geological engineer with 11 years of experience conducting geologic and hydrogeologic investigations, characterizations, and corrective actions. He has worked on a number of RCRA and Superfund investigation and remediation projects during that period. Mr. Brinkley has worked on environmental investigations at the 3200 Main Street Facility since 1990.

8.2 PROJECT SCHEDULE AND REPORTING

The Respondents will provide EPA with the following CMS deliverables according to the schedule below:

Deliverables	Due Date
Exposure Pathway Analysis for cleanup standards (Technical Memo #1)	90 days after EPA approval of the CMS Work Plan
Identification of Risk Equations and Transport Models, plus Screening of Technologies and Development of Corrective Measures Alternatives (Technical Memo #2)	60 days after approval of Technical Memo #1
Media Cleanup Standards (Technical Memo #3)	60 days after approval of Technical Memo #2
Draft CMS Report	60 days after approval of Technical Memo #3
Final CMS Report	45 days after receipt of EPA comments on the draft CMS Report

Figure 3 presents a timeline schedule based on the submittal dates presented above. Table 2 presents a preliminary outline for the CMS Report. The approval date for the CMS Work Plan and the time required for EPA review of submittals have been estimated to allow for completion of the timeline schedule. In addition, ongoing project activities such as groundwater sampling and operation of the SVE system have been included on a separate timeline on the schedule.

ASTM. 1998. Standard Guide for Remediations of Groundwater by Natural Attenuation at Petroleum Release Sites.

Envirogen. January 30, 1998. Interim Measures Remediation Work Plan: Soil Vapor Extraction System Design.

Envirogen. May 1999. SVE Construction and Startup Report.

EPA. 1989. Risk Assessment Guidances for Superfund. Volume 1. Human Health Evaluation Manual.

EPA. May 1994. RCRA Corrective Action Plan.

EPA. 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater.

EPA. July 1999. RCRA Cleanup Reforms.

MWR. April 1, 1993. Soil Vapor Extraction Pilot Study.

URSGWC. 1999. Update of Current Conditions, Facility at 3200 Main Street, Keokuk, Iowa.

Woodward-Clyde Consultants. December 1991. Pre-Investigation Evaluation of Corrective Measures Technologies.

Tables

TABLE 1

METHODS OF ANALYSIS, HOLDING TIMES, AND SAMPLE CONTAINERS AND PRESERVATIVES FOR NATURAL ATTENUATION GROUNDWATER SAMPLES

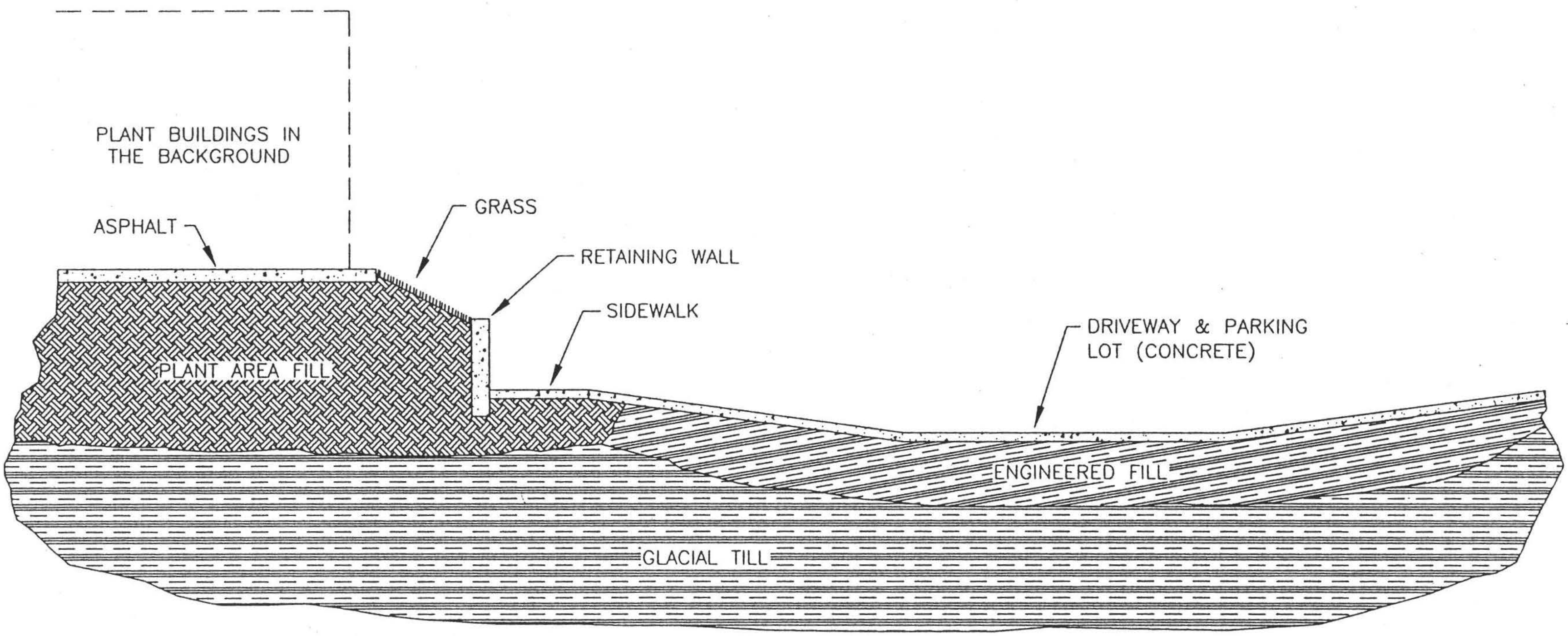
MONITORING PARAMETER	METHOD OF ANALYSIS[1,2]	HOLDING TIME	SAMPLE CONTAINER AND PRESERVATIVE[3]
Volatile Organic Constituents	EPA Method 8260B	14 Days	3 – 40-mL volatile organic analysis (VOA) vials with HCL to pH < 2
Volatile Fatty Acids			
Methane, Ethane, Ethene, Propane, Propene	Robert S. Kerr (RSK) 175	14 Days	3 – 50-mL glass serum bottles with gray butyl/teflon-faced septa and crimp top
Total Organic Carbon (TOC)	SW-846 Method 9060	28 Days	500-mL amber glass bottle with H_2SO_4 to pH < 2
Arsenic	EPA Method 6010B (trace ICP)	6 Months	100-mL plastic bottle with HNO_3 to pH < 2
Iron (II) (Fe^{+2})	Hach Field Test Kit[1]	---	---
Manganese	EPA Method 6010B (trace ICP)	6 Months	100-mL plastic bottle with HNO_3 to pH < 2
Calcium/Potassium/Sodium	EPA Method 6010B (trace ICP)	6 Months	100-mL plastic bottle with HNO_3 to pH < 2
Chloride	EPA Method 300.0	28 Days	250-mL glass bottle
Nitrate	EPA Method 300.0	14 Days	250-mL plastic bottle with H_2SO_4
Sulfate	EPA Method 300.0	28 Days	250-mL plastic bottle
Sulfide	Hach Field Test Kit[1]		
Alkalinity	EPA Method 310.1	14 Days	250-mL plastic bottle
Biochemical Oxygen Demand (BOD)	EPA Method 405.1	48 Hours	1-L plastic bottle
pH/Temperature/Conductivity	Field Measurement	---	---
Dissolved Oxygen	Field Measurement [4]	---	---
Oxidation-Reduction Potential	Field Measurement	---	---

Notes:
1 Or equivalent.
2 EPA accepted field monitoring techniques for lab samples may be substituted where applicable.
3 All samples preserved @ 4°C.
4 Dissolved oxygen will be measured using both flow-through and in-situ meters if the well diameter permits

TABLE 2

Preliminary CMS Report Outline
Facility at 3200 Main
Keokuk, Iowa

Section 1.0	**Introduction**
	1.1 Purpose of the CMS Report
	1.2 CMS Report Organization
Section 2.0	**Summary Review of Current Conditions**
	2.1 Facility History and Layout
	2.2 Contaminant Source Areas
	2.3 Degree and Extent of Contamination
Section 3.0	**Summary Review of Agreed Media Cleanup Standards**
Section 4.0	**Corrective Action Objectives**
Section 5.0	**Summary Review of Preliminary Screening of Technologies and Development of Corrective Measure Alternatives**
	5.1 Preliminary Screening of Technologies
	5.2 Development of Corrective Measure Alternatives
Section 6.0	**Detailed Evaluation of Corrective Measure Alternatives**
	6.1 Evaluation Criteria
	6.2 Evaluation of Alternative 1
	6.3 Evaluation of Alternative 2
	6.4 Evaluation of Alternative 3 (as needed)
Section 7.0	**Recommendation and Justification of a Corrective Measure for the Site**
	7.1 Recommended Alternative
	7.2 Justification of the Recommended Alternative
Section 8.0	**Summary and Conclusions**
Section 9.0	**References**



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PROJECT MGR.	J. WHITNEY
DRAWN	TRY
DWG NAME	contamination zones
PROJECT NO.	55005
DATE	11-29-99

ENVIROGEN

INNOVATIVE SOLUTIONS FOR ENVIRONMENTAL PROBLEMS
5126 WEST GRAND RIVER AVENUE
LANSING, MICHIGAN 48906

KEOKUK SITE
KEOKUK, IOWA

CROSS-SECTION SCHEMATIC SHOWING
3 ZONES OF SOIL CONTAMINATION

FIGURE NO. 1

FIGURE 2
PROJECT ORGANIZATION CHART

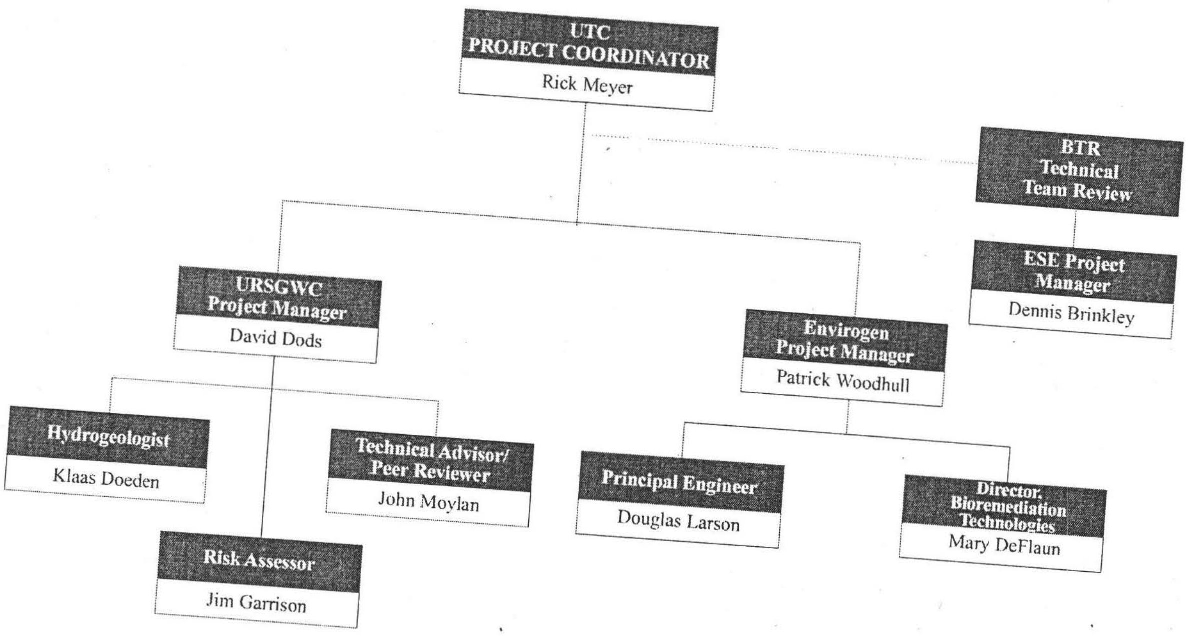
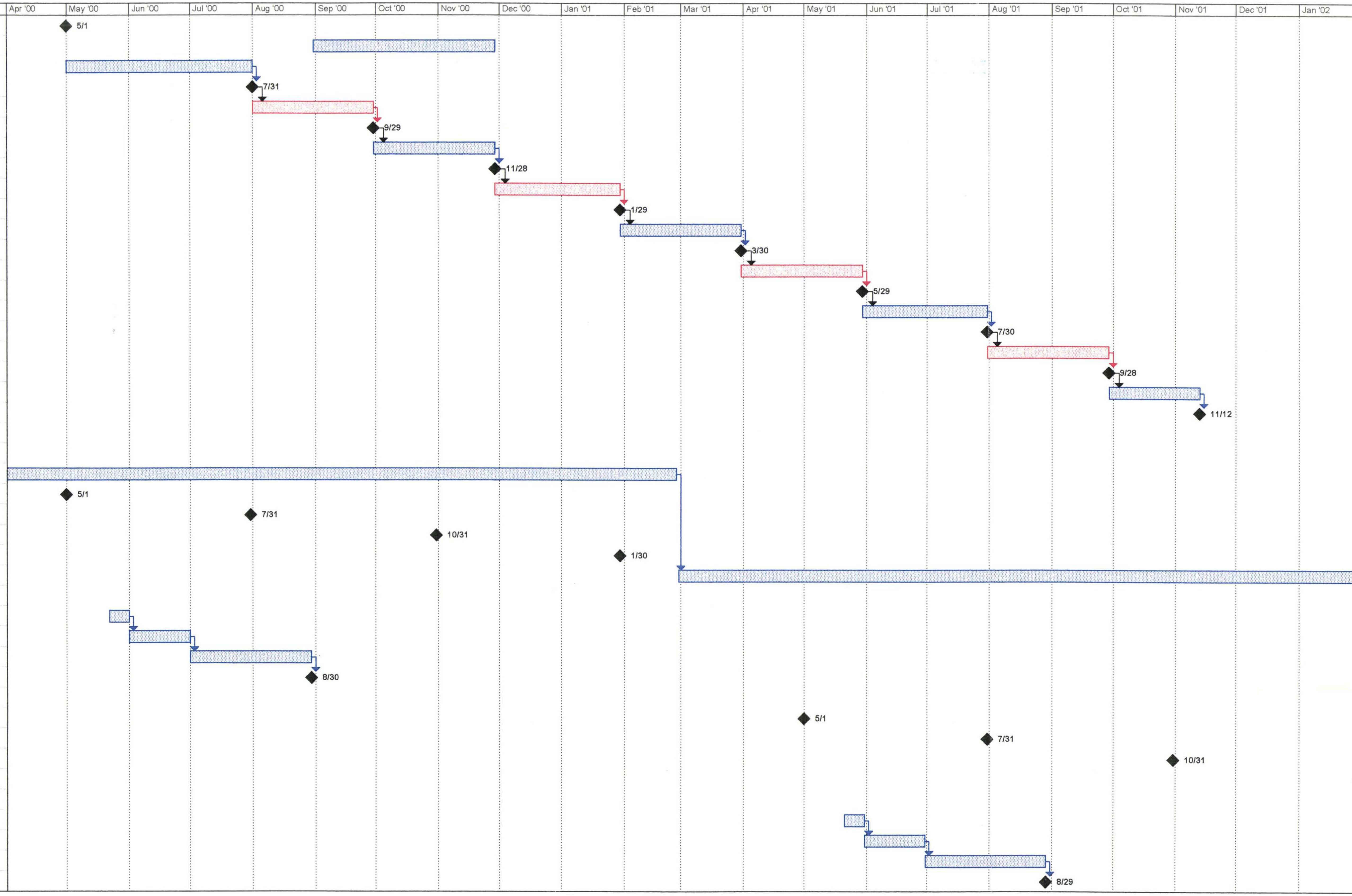


FIGURE 3
SCHEDULE OF ACTIVITIES
FACILITY AT 3200 MAIN STREET, KEOKUK, IOWA

ID	Task Name	
1	EPA Approves CMS Work Plan	5/1
2	Preliminary Screening of Technologies	
3	Exposure Pathway Analysis	
4	Submittal to Technical Memo #1	7/31
5	EPA Review of Technical Memo #1	
6	EPA Approval of Technical Memo #1	9/29
7	Identification of Risk Equations and Transport Models	
8	Submittal of Technical Memo #2	11/28
9	EPA Review of Technical Memo #2	
10	EPA Approval of Technical Memo #2	1/29
11	Calculation of Media Cleanup Goals	
12	Submittal of Technical Memo #3	3/30
13	EPA Review of Technical Memo #3	
14	EPA Approval of Technical Memo #3	5/29
15	Preparation of Draft CMS Report	
16	Submittal of Draft CMS Report	7/30
17	EPA Review of Draft CMS Report	
18	EPA Provides coments to Draft CMS Report	9/28
19	Revisions to Draft CMS Report	
20	Submittal of Final CMS Report	11/12
21		
22	SVE System Operation (Year 1)	
23	SVE System Operation (Year 2)	
24	SVE First Qtr 2001 Operations Report	5/1
25	SVE Second Qtr 2001 Operations Report	7/31
26	SVE Third Qtr 2001 Operations Report	10/31
27	SVE Fourth Qtr 2001 Operations Report	1/30
28	SVE System Operation (Year 3)	
29		
30	May 2000 GW sampling	
31	Laboratory Analysis	
32	Preparation of 2000 Annual GW Monitoring Data Report	
33	Submittal of 2000 Annual GW Monitoring Data Report	8/30
34		
35	SVE First Qtr 2000 Operations Report	5/1
36	SVE Second Qtr 2000 Operations Report	7/31
37	SVE Third Qtr 2000 Operations Report	10/31
38	SVE Fourth Qtr 2000 Operations Report	
39		
40	2001 Annual GW Sampling	
41	Laboratory Analysis	
42	Preparation of 2001 Annual GW Monitoring Report	
43	Submittal of 2001 Annual GW Monitoring Report	8/29



Project: Schedule
Date: Thu 3/9/00

Task | Progress | Summary | Rolled Up Split | Rolled Up Progress | Project Summary
Split | Milestone | Rolled Up Task | Rolled Up Milestone | External Tasks